ENGINEERS & GEOSCIENTISTS BC

PHYSICAL CLIMATE RISK ASSESSMENT

RDH REF: 30001.000

FEBRUARY 18, 2025

Prepared for

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

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By

RDH BUILDING SCIENCE

Contents

1.0 Introduction

RDH Building Science (RDH) is providing this report to summarize the results of our Physical Climate Risk Assessment for the Engineers and Geoscientists BC office building located at 4010 Regent Street in Burnaby, British Columbia. It represents our final deliverable for this scope of work.

This is a screening-level climate risk assessment based on the PIEVC High Level Screening Guide (released in February 2022). It is a more condensed, streamlined version of the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol assessment framework, and is an appropriate level of assessment to inform capital planning.

1.1 Assessment Intent

Engineers and Geoscientists BC is developing an organizational climate change strategy, building on its Climate Change Action Plan and 2022-2027 Strategic Plan. Associated actions include those that support registrants, as well as internal activities to model responsible action and address physical climate risk.

Historical codes (Canadian and provincial) and design standards do not reflect current and future climate related impacts and risks, and while some standard approaches to climate risk assessment have been developed, many professional registrants working in BC's building industry have questions about how to incorporate these considerations into their own work, and in particular, how to apply them to existing buildings.

Further to its mission to lead by example, Engineers and Geoscientists BC requested that a physical climate risk assessment be conducted on the property it owns and that houses its head office, located at 200-4010 Regent Street, in Burnaby, British Columbia. The purpose of this physical climate risk assessment was thus three-fold:

1. To add a climate lens to Engineers and Geoscientists BC's corporate asset management planning (Engineers & Geoscientists BC intends to use this risk assessment to inform both asset renewal and future space capacity planning work),
2. To create and share a sample project deliverable that may prove instructive for registrants working on other existing building projects within BC, and
3. To pilot the Climate Resilience Framework and Standards for Public Sector Buildings (CRFS) v. 1.0 document, which was released internally with the province's new Environmental, Social and Governance (ESG) framework and includes proposed minimum climate resilient design standards (*Standards*) for existing building retrofits.

More specifically, the objectives of the project were to:

1. Identify the medium and high climate risks to the building's systems and site;
2. Propose adaptation measures to address the medium and high risks identified; and
3. Prioritize the adaptation strategies based on our understanding of Engineers and Geoscientists BC's near-term renewal plans, order of magnitude cost, ease of implementation and maintenance, and importance for climate-risk adaptation. A scoring system was developed to evaluate at a high-level the 'return on resilience investment' of each adaptation measure considered.

A detailed summary of the project methodology is provided in **Appendix A**.

2.0 Summary of Results

2.1 Climate Trends and Future Climate Design Parameters

The following climate trends for Burnaby, British Columbia were identified as part of the climate risk assessment:

- Warmer summers[1] and more extreme high summer temperatures (i.e. heat waves)
- Warmer winters[2] and less severe cold snaps (i.e. less frequent, and potentially less cold)
- Reduction in total annual snow accumulation and in severity of snow/ice storm events
- Increased total annual precipitation (due to an increase in annual rainfall)
- Increased severity and frequency of high-intensity short-duration rainfall events
- Increased frequency and severity of wildland urban interface forest fires, and wildfire smoke events

Appendix B summarizes the projected climate design parameters for the years 2050 and 2090. These, along with the climate trends noted above, were determined from available downscaled regional climate model data[3], and assume that future rates of greenhouse gas and aerosol emissions into the atmosphere remain the same as they are currently.

2.2 Key Takeaways and Recommendations

Built circa 1995, Engineers and Geoscientists BC's office at 4010 Regent Street is nearly 30 years old. Originally designed with high performance in mind, several of the building's design features provide a degree of climate resilience that other buildings designed around the same time might not have.

Below we summarize the key findings and best value recommendations for each of the major building systems.

Mechanical Systems

The primary **heating and cooling system** consists of zone level water-source heat pumps installed in the office ceiling spaces and connected to a ground source geo-exchange field installed underneath the grade level parking area. The geo-exchange system acts like an energy storage battery that enables the heat pumps to reject or extract heat to increase the heat pump efficiency and capacity. The system is thus very efficient and already exceeds the province's CleanBC targets

[1] Rising temperatures, as indicated by the increase in cooling degree days, may also suggest an extended summer season.

[2] Rising temperatures, as indicated by the decrease in heating degree days, may also suggest a shortened winter season.

[3] Projected design values and climate trends were taken primarily from Cannon et al., "Climate-Resilient Buildings and Core Public Infrastructure" (2020), and climatedata.ca.

of minimum 100% efficient heating and cooling equipment, and given that the system is all-electric, is considered near zero operating carbon.

The "Geo-Exchange/Ventilation Systems Review Report" by Prism Engineering (2023) noted that the typical failure of geo-exchange systems is gradual, resulting in reduced capacity. Prism assessed the geo-exchange field's thermal performance through monitoring supply and return temperatures over a period of time, and identified no performance issues. They also noted that geo-exchange fields can operate reliably years after the expected life (20 to 50 years). They recommended installing permanent performance monitoring system and periodically monitoring for performance changes; this could become more important as reliance on the system for cooling increases.

In 2019 (pre-Covid pandemic)[4], the building's annual energy consumption was approximately 264,000 kWh[5], which corresponds to a total site energy use intensity (TEUI)[6] of approximately 145 kWh/m^2/year. This is below the ASHRAE 100, BC Specific, Climate Zone 4, 25th percentile TEUI target for office buildings (155 kWh/m^2/year) and well below the average of 222 kWh/m^2/year.[7]

According to Facilities staff, the space conditioning system was able to provide comfort cooling during the 2021 heat dome, indicating that the system has spare capacity for extreme heat events that will likely be sufficient throughout the remaining service life of the mechanical equipment. Engineers from Prism Engineering estimated the cooling capacity of the existing system at 50 to 60 tons. Looking towards the 2050 and 2090 time horizons, when components (e.g. heat pumps, ground loop components) come up for replacement, ***it is recommended that the mechanical engineer size any new system components (including zone level heat pumps) using projected climate data at the end of the anticipated new equipment service life and/or consider supplemental independent equipment such as air source heat pumps to meet future demand.***

The **ventilation system** consists of two (2) distributed makeup air (MAU) units without heat recovery- one located in the ceiling space above the lower level lunchroom and the other located in the ceiling of the upper level office space. The office unit was turned off due to noise complaints. The MUA units are supplied with MERV-8 filters. Fourteen (14) standalone Citron Jade 2.0 air purifiers with HEPA filtration, activated carbon filtration and UV decontamination were purchased as a COVID response and continue to operate throughout the space to filter and recirculate air. The bathrooms have no dedicated exhaust and recirculating SaniZone air purifiers were installed as a retrofit.

The installed mechanical ventilation system is inadequate as currently operating and may be causing air movement and/or air quality concerns for occupants (in addition to the reported noise complaints). The standalone air purifiers are mitigating the air quality issue although Engineers and Geoscientists BC may want to consider a more comprehensive solution that not only provides a more permanent indoor air quality solution but also addresses the noise complaints that accompanied the original MUA system. As it relates to climate risk, the air purifiers – provided there are enough of them to service all occupied areas – exceed the minimum recommended filtration level of MERV-13 filters to protect against wildfire smoke. HEPA with activated carbon filtration offers the highest level of protection against wildfire smoke impacts, although this level of filtration can be impractical at the system level (space requirements for these filters likely exceed available space

[4]During the years of the pandemic and immediately post-pandemic (2020-2023), electricity consumption (& therefore TEUI) was lower than the 2019 value.

[5]PUMA Report, dated Nov. 30th, 2023

[6]Total energy use intensity, abbreviated to 'TEUI,' is calculated as the annual energy consumption divided by the conditioned floor area.

[7]ASHRAE 100 Users' Guide; https://neea.org/resources/ashrae-100-users-guide

within the existing MUA units and fan energy is increased to push the air through). It is our understanding that Engineers and Geoscientists BC plans to replace the MUA system in the near future, with quieter heat recovery units. ***It is recommended that the replacement of the existing MUA units be prioritized given the increasing prevalence and severity of wildfire smoke events, and that the new system be selected/designed to accommodate MERV 13 filters at a minimum.*** The standalone HEPA/activated carbon air purifiers can supplement as needed, although Engineers and Geoscientists BC should confirm with the manufacturer that the number of units and layout of system can handle the contaminant makeup and concentrations associated with wildfire smoke events. An indoor air quality evaluation could be performed during a wildfire smoke event to evaluate the efficacy of the system.

Domestic hot water is provided by a domestic water heater installed circa 2010. Because water use is relatively low in an office setting and would not be considered a critical service, we have no associated recommendations related to mitigating climate risk although Engineers and Geoscientists BC could consider installing a heat pump water heater at the time of equipment renewal as a climate change mitigation strategy.

Electrical Systems

Electrical services connect to the building via underground conduit and enter the main electrical room located on the ground floor.

The building has an on-site server room that is currently being fully backed up in Kelowna daily. The server room is cooled by two (2), two-ton mini-split heat pump units. The main climate-related risk as it relates to electrical systems is potential damage to the server room heat pump outdoor units located at grade (e.g. extreme rain, wind, or snow event) that would then limit the functioning of the air conditioning system. It is our understanding that the system will be transitioning to a Tier 3 data center which will provide a higher level of resilience via cloud-based and off-site servers.

There has also been a leak reported in the main electrical room through a conduit sleeve that penetrates to the exterior of the building. ***It is recommended that all penetrations near-grade be reviewed regularly for adequate sealing.***

Building staff indicated that they operated the building as a cooling centre for their staff during the 2021 heat dome (i.e. staff who would normally work from home were offered space to work in the office if their homes were uncomfortable). The building does not currently have a generator, and the only backup power is to enable short-term (30-minute) server backup in the event of a power outage via a UPS system. Engineers and Geoscientists BC could ***consider adding some level of backup generation capability (including via photovoltaic generation with battery storage[8]) if it wants to maintain operation and possibly act as a place of refuge for its staff during an extreme climate event or widespread power outage.***

Building Enclosure System

The building enclosure on the north, south and east elevations consists primarily of aluminum framed curtain wall. The west elevation is clad in pre-formed, prefinished metal panels. Fixed, tempered glass shading devices were installed on the south and east elevations of the building to

[8] As of July 2024, BC Hydro is offering solar and battery rebates for business and residential customers. Please refer to the following link for more info: https://app.bchydro.com/accounts-billing/electrical-connections/self-generation.html

provide glare and direct solar gain protection. The roof consists of rock ballast and paver walkways above an EPDM roofing sheet above rigid insulation.

The building's airtightness was tested in 2018 and was found to be relatively airtight (0.41 L/s/m^2 at 75 Pa).[9]

The building enclosure has been well-maintained, with minimal signs of failed sealant or unwanted air infiltration. This provides good protection from unwanted air infiltration in the event of a wildfire smoke event.

The main risk from a climate impacts perspective is the high percentage of glazing, which offers minimal thermal resistance. Some hot spots were noted by Facilities staff - primarily the lower south side of the building where staff avoid sitting due to solar gains on the. The fixed shading and tinted glazing provide only partial protection from glare and unwanted solar gain, and as such the building is very reliant on the mechanical heating and cooling system to maintain space temperature. Fortunately, the mechanical system is very efficient, although the building would be vulnerable to temperature swings in the event of a power outage. ***The most cost-effective response to this vulnerability would likely be to implement some level of backup generation capacity (e.g. photovoltaic with battery storage) to maintain operation of key systems in the event of a power outage. As a low-cost measure, Engineers and Geoscientists BC could also plant fast growing shade trees on the south side of the site to mitigate overheating issues in the identified hot spots. Movable shading or reflective films could also be considered as temporary measures.***

Civil and Site Systems

While there have been no reported issues with the civil and site systems (the key concern being roof and site drainage as it relates to climate risk), including during the 2021 extreme atmospheric river, there are two potential areas of risk:

1. A potential extreme rainfall event that overloads the roof or site drainage system and could be exacerbated by the grade sloping toward the building at the west side of the building.
2. A potential extreme rainfall event that floods nearby Still Creek and restricts access to/from the building. While the building itself is outside the identified flood plain (refer to City of Vancouver's Open Data Portal), roads connecting staff to the site have flooded in the past and could pose an access risk in the future. For example, Boundary Road, a major arterial, is at the edge of the floodplain.

It is recommended that roof and site drainage systems be inspected and cleaned regularly. At time of roof renewal, it is recommended that the roof drainage system be re-evaluated and potentially upgraded to accommodate storm events sized to end of building's design service life (using climate-projected IDF curves with a safety factor).

Engineers and Geoscientists BC should consider alternate access or emergency egress plans to strengthen operational continuity considerations.

[9] For reference, this is only slightly higher than the Passive House Institute value of 0.4 L/s/m^2, and is well under the ASHRAE 90.1-2016 target of 2.0L/s/m^2.

Comments on the Minimum Climate Resilience Standards as Applied to Existing Buildings

Chapter 3 of the Climate Resilience Framework & Standards for Public Sector Buildings (CRFS) contains a set of minimum standards (the Standards) for the retrofitting of existing buildings for climate resilience. The Standards for existing buildings were used as a starting point for developing adaptation strategies in response to the climate hazards at Engineers and Geoscientists BC's office. RDH was the lead author on the development of CRFS document, and to our knowledge, this is the first existing building that has used the Standards for existing buildings for developing adaptation strategies in response to a climate risk assessment.

Over the course of the project, it became apparent that several of the standards, while they would mitigate identified climate risks, would be cost-prohibitive or infeasible to implement in an existing building context. This was expected during the development of the Standards; however, it does highlight that for certain buildings, the development of adaptation strategies will rely more heavily on the expertise of the consultant team. In the context of existing buildings, it is suggested that the Standards be updated to reflect feedback from professionals as they apply them to projects, and that they be used as a starting point rather than definitive direction for folding climate risk considerations into every existing building project. We also understand that V 2.0 of the CRFS will include a modified approach and simplified checklist for existing buildings, which may address these comments.

2.3 Medium and High Climate Risks & Associated Adaption Strategies

Tables 2.1 through 2.5 summarize the results of the climate risk assessment for the various building sub-systems. These tables focus on the 'medium' and 'high' level risks identified. The recommended adaptation strategies to mitigate this risks are presented in the fifth column of each table, where they have been identified as low, medium or high priority.

TABLE 2.1 KEY CLIMATE RISKS & ADAPTATION STRATEGIES FOR MECHANICAL SYSTEMS				
Climate Hazard	Building System	Risk Level	Interaction/Comments	Key Strategies for Climate Adaptation
Heat Waves & Warmer Summers	Space Cooling Systems	LOW (2050) - MEDIUM (2090)	Prism's "Geo-exchange/ventilation Systems Review Report" stated that no current performance issues have been identified, although given that the system is nearly 30 years old, elements of the system could fail at any time, and/or performance can gradually degrade over time. Operational staff noted that the geothermal/heat pump system was able to handle the 2021 heat dome event loads well, so we expect that the system has some additional capacity and may be resilient to extreme heat events in the near term. However, Engineers and Geoscientists BC has received some complaints related to climate control (warmer space in lower south portion of the building because of thermal gains) and that awnings provide limited relief at these locations. Capacity relative to the 2090 time horizon is unknown, although component equipment is expected to go through multiple renewal cycles before then. The existing mechanical system already meets the CleanBC low-carbon requirements, being all-electric heat pumps + geothermal exchange loop with a relatively high system efficiency.	→ **(MEDIUM PRIORITY)** Recommend that when component cooling equipment is replaced at end of life, the mechanical engineer size the system to account for cooling loads for its full design service life (and the climate-projected design values be re-evaluated if new climate model information is available at that time). **NOTE:** *Engineers and Geoscientists BC staff confirmed that the heat pumps are in the process of being replaced; it is recommended that Engineers and Geoscientists BC confirm with the mechanical designer whether projected climate was considered during equipment sizing/selection.* → **(MEDIUM PRIORITY)** Engineers and Geoscientists BC could consider installation of back-up generation that could be sized to provide life safety back-up for the whole building, and/or non-life safety back-up (e.g. space cooling) for designated refuge spaces.
Extreme Rainfall & Increase in Total Annual Precipitation *+ Associated Flooding Events*	All Mechanical Equipment	MEDIUM (2050 and 2090)	Damage to critical mechanical equipment from floodwaters (at ground level) may result in: o Loss of building services o Costly equipment repairs or replacement o Downtime Based on conversation with Engineers and Geoscientists BC team, flooding and ponding water have not been concerns to date on-site; however, grade slopes towards the building on the West elevation, and the building has proximity to impervious surfaces that could direct runoff towards the building or site.	→ **(HIGH PRIORITY)** Until time of equipment renewal, ensure that at-/near-grade building enclosure is in reliable condition (ensure that no penetrations could act as pathways for water ingress). → **(HIGH PRIORITY)** At time of roof renewal, upgrade roof drainage system to accommodate storm events sized to end of building's design service life (circa 2090; using climate-projected IDF curves). Currently, there are internal roof drains that discharge into underground storm lines at south end of building and a scupper on the west side. Ensure that at time of roof renewal, scupper drains are placed a maximum distance of 30m around the perimeter of the roof (unless otherwise determined by a licensed qualified professional). → **(MEDIUM PRIORITY)** With aging infrastructure, water can find pathways into the building. The building should be able to function with essential building services during a flood event. At time of mechanical system renewal, consider whether equipment susceptible to damage by floodwaters should be relocated above grade or placed on pedestals and whether electrical conduits should be relocated.
Wildfire Smoke Events	Indoor Air (Quality)	MEDIUM (2050 and 2090)	The current mechanical ventilation system uses MERV-8 filters, supplemented by multiple standalone HEPA/carbon-activated/UV air purifiers that were installed throughout the office as a COVID response. MERV-13 filters are recommended as a minimum level of filtration to provide protection (while not complete) against wildfire smoke events. The standalone air purifiers exceed this minimum. *A related building enclosure note* - The building is also relatively airtight, which will prevent unwanted air infiltration in the event of a wildfire smoke event.	→ **(MEDIUM PRIORITY)** At the time of system replacement, recommend that a system compatible with min. MERV-13 air filters be selected. → **(MEDIUM PRIORITY)** If upgrades to the ventilation system are anticipated to be delayed more than a few years (and Engineers and Geoscientists BC would like to solely rely on air purifiers for filtration), it is recommended that an indoor air quality evaluation be performed during a wildfire smoke event to evaluate their efficacy. This evaluation could also provide information prior to MUA system renewal to see if current system is sufficient for extreme smoke events.

TABLE 2.2 KEY CLIMATE RISKS & ADAPTATION STRATEGIES FOR ELECTRICAL SYSTEMS				
Climate Hazard	Building System	Risk Level	Interaction/Comments	Key Strategies for Climate Adaptation
Heat Waves & Warmer Summers	Server Room	LOW (2050) - MEDIUM (2090)	The server room uses zone level mini-splits heat pumps to ensure that sensitive equipment does not malfunction. Temperature of server room(s) should be between 18 and 27°C; optimal range is 20-22°C (which they appear to be currently). Higher outdoor temperatures can lead to increased electricity demand for cooling systems (which can strain the grid). While this is not currently a major concern, this could become one in the future as more buildings decarbonize. If demands exceed capacities, this may result in blackouts/brownouts - consider how the temperatures in this room may be affected in the instance where no cooling is provided to the space. Brief interruption to services and normal administrative/operational difficulties could occur in case of a brownout or equipment malfunction.	→ **(MEDIUM PRIORITY)** Ensure that maintenance for mini-split systems is performed before the summer season. At time of equipment renewal, a mechanical engineer should confirm their capacity given current and anticipated loads (refer to Table 2.1 for adaptation strategies regarding mechanical systems). → **(MEDIUM PRIORITY)** It is our understanding that Engineers and Geoscientists BC will be transitioning to a Tier 3 data center, which would provide climate resilience by moving its data systems and backup to the cloud. [Currently a full backup of data is being replicated to Kelowna, which already limits data loss in any event of equipment failure or outage.]
	Elevator	LOW (2050) - MEDIUM (2090)	Brief interruption (several days to a week) in case of equipment damage. Access/egress restrictions to/from second level while elevator is out of service.	→ **(MEDIUM PRIORITY)** Currently, it is reported that temperatures in elevator room remain comfortable throughout the year. If this were to change (e.g. 2090 time horizon), consider adding minisplit unit or other space cooling to the elevator room to maintain temperature setpoints.
	Power Distribution Systems	LOW (2050) - MEDIUM (2090)	Higher outdoor temperatures can lead to increased grid-level electricity demand for space cooling systems (which can strain the grid). While this is not currently a major concern, and this building has some built in resilience via its geo-exchange system, blackouts/brownouts could become more common in the future. High temperatures can lead to overheating in transformers, circuit breakers, and other components, risking failure or reduced efficiency. Elevated temperatures can accelerate the aging process of insulation materials on cables, potentially leading to failures.	→ **(MEDIUM PRIORITY)** Refer to recommendations in Tables 2.1 and 2.3 to protect electrical distribution equipment from extreme heat events.
Extreme Rainfall & Increase in Total Annual Precipitation *+ Associated Flooding Events*	All Electrical Equipment	MEDIUM (2050 and 2090)	Damage to critical electrical equipment from floodwaters (at ground level) may result in: o Loss of building services, o Costly equipment repairs or replacement, o Downtime. Any conduits that become exposed to water may result in short circuiting of equipment. Based on conversation with Engineers and Geoscientists BC team, flooding and ponding water have not been concerns to date on site; however, grade slopes towards the building on the West elevation, and the building has proximity to impervious surfaces that could direct runoff towards the building or site.	→ (**MEDIUM PRIORITY**) The building should be able to function with essential building services during a flood event. The following are recommendations based on understanding that as buildings age, water ingress becomes more common (from flash flooding or other): → At time of renewal, if possible, relocate equipment susceptible to damage by floodwaters and safety equipment (e.g. transfer switches) above grade plus a buffer as determined by the Civil design team, unless other reasonable measures are taken to prevent or protect against flooding (as determined by a licensed qualified professional). This can include relocation of electrical connections. **NOTE:** *"Above grade plus a buffer" should reference Minimum Building Elevations accounting for climate change- if available- from the municipality.* → At time of elevator renewal, the controls are to be designed to prevent the cab from descending into floodwaters. The 2021 Stantec Report notes that due to its age and typical design service life, "significant repairs and modernization are anticipated" soon. → **(HIGH PRIORITY)** Ensure that at/near- grade building enclosure is in reliable condition i.e. no penetrations create pathways for water ingress

TABLE 2.3 KEY CLIMATE RISKS & ADAPTATION STRATEGIES FOR BUILDING ENCLOSURE				
Climate Hazard	Building System	Risk Level	Interaction/Comments	Key Strategies for Climate Adaptation
Heat Waves & Warmer Summers	Fenestration and Door Assemblies	MEDIUM (2050 and 2090)	Some 'hot spots' have been observed in the building regardless of mechanical cooling system operation. Awnings have been reported to have limited impact at the lower south space and thermal gains are causing staff discomfort complaints. In future climate, this will likely be aggravated. Except for the hot spots noted, the mechanical cooling is reported to maintain occupant thermal comfort, although the building has limited passive survivability (the ability to maintain temperature in the event of a power outage). Passive survivability through conscious building enclosure design (or use of generator back-up for non-life safety loads) is likely to become more important in the future as demands on electricity grid get closer to peak, and as the severity and frequency of extreme heat events increases. Single glazed doors have no insulative properties (therefore poor thermal performance), negatively impacting thermal comfort and energy consumption.	At time of building enclosure renewal, select high performance building enclosure materials to improve thermal performance: → **(MEDIUM PRIORITY)** For replacement of punched windows and curtain wall, consider triple paned glazing with a low solar heat gain coefficient and low U-value. → **(HIGH PRIORITY)** Likewise ensure that single paned doors are replaced with higher performance assemblies at time of renewal. → **(MEDIUM PRIORITY)** Consider planting fast growing shade trees on the south side of the building.
Extreme Rainfall & Increase in Total Annual Precipitation *+ Associated Flooding Events*	Below Grade Assemblies	MEDIUM (2050 and 2090)	Damage/failure of the below- and at-grade building assemblies from floodwaters may result in: o Loss of building services, o Damage to building contents, o Downtime. It is our understanding that to-date, there have been no concerns and leaks have been limited to one leak through an at-grade electrical conduit penetration. The building does not have a basement, so flooding of the building would be limited to at-grade level.	→ **(HIGH PRIORITY)** Ensure penetrations are sealed, and glazing and other joints are properly caulked and maintained. → **(MEDIUM PRIORITY)** Generally, the building cladding materials near grade are non-absorbent already. When significant building enclosure renewals occur, enclosure materials that are non-absorbent and flood damage-resistant must be selected for areas near or at grade.
Wildland Urban Interface Fires & Wildfire Smoke Events	Fenestration and Door Assemblies	MEDIUM (2050 and 2090)	Single paned windows, such as the single-paned doors, have limited wildfire urban interface fire resistance. Damage/failure of the building assemblies from wildfire may result in: o Loss of building services, o Damage to building contents, o Downtime.	→ **(MEDIUM PRIORITY)** At time of building enclosure renewal, design engineer to consult select construction materials per NRC's "National guide for wildland-urban interface fires" (2021).10 At minimum, materials are to be 'ignition-resistant.' → **(MEDIUM PRIORITY)** Exterior glazing must satisfy the following sub-requirements: i) Glazing must be multi-layered (i.e. at minimum, dual pane) with an outer pain of tempered or heat-strengthened glass. ii) Windows and skylights must be tested using SFM Standard 12-7A-2, Exterior Windows. → **(MEDIUM PRIORITY)** Exterior doors must satisfy the following sub-requirements: i) Doors must be made of non-combustible assemblies. ii) Glazing in doors must satisfy relevant sub-requirements of 3.1.d) above.

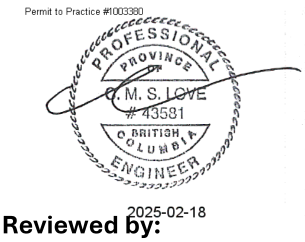
[10] Benichou et al., "National guide for wildland-urban interface fires: guidance on hazard exposure, property protection, community resilience and emergency planning to minimize the impact of wildland-urban interface fires" (2021)

TABLE 2.4 KEY CLIMATE RISKS & ADAPTATION STRATEGIES FOR CIVIL & SITE SYSTEMS				
Climate Hazard	Building System	Risk Level	Interaction/Comments	Key Strategies for Climate Adaptation
Extreme Rainfall & Increase in Total Annual Precipitation *+ Associated Flooding Events*	Stormwater Management System	MEDIUM (2050 and 2090)	Possibly a major loss of capacity since it is not designed for future climate (2050), which projects an approx. 13% increase in intensity of extreme rainfall events. Possibly major loss of function (2090), which projects an approx. 31% increase in intensity of extreme rainfall events. The above could result in localized ponding, and/or flooding of building if there are any weaknesses in below-/at-grade waterproofing, which may further result in: o Loss of building functionality & services, o Damage to building contents from floodwaters, o Downtime, o Reduced site access/egress. Cost of damage is highly variable. Access to site may be impacted by flooding of Still Creek.	**(HIGH PRIORITY)** If Engineers and Geoscientists BC plans to retain its office location in the long-term, we recommend that a detailed assessment of the stormwater drainage and detention capacity be performed. The system should be able to accommodate storm events that consider climate change to the end of design service life for the building. Recommendations for the upgrade of stormwater drainage and detention systems during renovation/renewal if deemed appropriate by a licensed professional: o Ensure that upgrades for infiltration, capture and conveyance systems account for adjusted climate projections based on end of design service life IDF curves. o On-site stormwater capture and detention capacities should be increased. On-site detention capacity can be increased using non-infiltrating storage devices (e.g. underground detention tanks) and/or green infrastructure (e.g. rain gardens, permeable pavements, infiltration trenches, rainwater tree trenches). Vegetative strategies have co-benefits such as urban cooling and increased biodiversity. o On-site stormwater facilities should be designed to have a safe overflow route. For example, when the detention feature exceeds its designed inflow or there's a blockage at the outlet, there is a passive failure flow path for the excess water to travel without flooding the building or impacting public/staff safety. (This recommendation was not included in the CRFS Standards.) o 90 percent of the average annual rainfall volume that falls on vehicle-accessible and other pollutant-generating surfaces should be captured and treated on site. o Where possible, modify the property grade of non-impervious surfaces (for the entire building perimeter) to slope down and away from building at a minimum of 5 percent slope for a minimum distance of 6 meters. **(MEDIUM PRIORITY)** Engineers and Geoscientists BC should consider alternate access or emergency egress plans to strengthen operational continuity considerations (This recommendation was not included in the CRFS Standards.)
Wildland Urban Interface Fires	Landscaping & Grounds	MEDIUM (2050 and 2090)	There is wildland vegetation that could sustain wildfire spread within 500m of the structure. The vegetation (and any combustible elements) on site or in neighboring areas can act as a pathway to the building. If vegetation/site elements on site caught on fire from embers of a nearby fire, building and site elements would be at risk of damage. Building structure is non-combustible.	**(MEDIUM PRIORITY)** Vegetation and landscaping within 10 metres of the building foundations should be modified as required to minimize risk of wildland fires. The building site must be maintained free of dry grasses and fine fuels. o Follow recommended practices as per NRC's "National guide for wildland-urban interface fires" (2021) o Select wildfire-resistant vegetation such as those presented in FireSmart guidelines [Note that vegetation should also be drought resistant, native, and wherever possible, should provide passive shading to the building]. **(MEDIUM PRIORITY)** Unprotected heat sources are not permitted within 10 metres of the primary structure

3.0 Closure

We trust that this report adequately summarizes the results for the Physical Climate Risk Assessment, and that it will help Engineers and Geoscientists BC's team understand the climate risks associated with the building and its site, as well as provide prioritized adaptation strategies for climate resilience.

Yours truly,



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APPENDIX A: Methodology
APPENDIX B: Summary of Future Climate Projected Design Parameters
APPENDIX C: Likelihood Score, Consequence Score and Risk Score Definitions

APPENDIX A: Methodology

1.0 Preliminary Assessment

1.1 Reference Document Review

First, we reviewed relevant Engineers and Geoscientists BC-provided documents including:

- Construction documents including architectural, mechanical, electrical, structural, and civil drawings,
- Engineers and Geoscientist BC's most relevant policy, and operational & maintenance documentation, and
- Any other documents Engineers and Geoscientists BC deemed important (e.g. consultant reports).

1.2 Exposure Screen

The 'Exposure Screen' step of this project was based on the PIEVC High-Level Screen Guide (HLSG) and is consistent with Step 2 outlined in the "Climate Resilience Framework & Standards for Public Sector Buildings" (CRFS). The CRFS document provides detailed explanation and resources for how to conduct an 'Exposure Screen'; it is a good reference for anyone looking to conduct their own assessment or who wants additional information.

In summary, this step consists of the:

1. Identification of climate change-related hazards which are relevant to the Engineers and Geoscientists BC office and building site. More specifically, for each possible climate-change related hazard (warming climate and extreme heat events, flooding, wildfires and wildfire smoke events, strong wind events, cold snaps, extreme snowfall/ice storms, and droughts), the team identified whether the building was in an area previously impacted by the hazard and/or is anticipated to be impacted by the hazard as informed by climate projected data.
2. Identification of building components/systems to be considered in the climate risk assessment. This included a half-day site visit by the RDH team where key Engineers and Geoscientists BC staff and the Office & Facilities Manager were present.

1.3 Assumptions for determining Climate Projected Design Values & Overall Climate Trends

To assess the impact of climate trends on a building and compare the loads it was originally designed for with those it will face in the future, a number of climate indicators were selected. Wherever possible, building code design values (from the National Building Code of Canada) were selected as climate indicators. Comparing historical design values to projected future climate design values facilitates understanding of:

1. how climate trends may evolve, and
2. the potential changes in building loads.

1.3.1 Historical & Present-Day Values

Historical and present-day climatic design data values for Burnaby were obtained from the National Building Code of Canada.

Historical data values were obtained from the "Supplement to the National Building Code 1990." The Engineers and Geoscientists BC building's original design and construction (circa 1995) would likely have required compliance with the British Columbia Building Code (1992), which adopted the NBC 1990 code.

Present-day climate data values were obtained from Appendix C of the "National Building Code of Canada 2020."

1.3.2 Projected Climate Design Values

Projected climatic design values for the 2050- and 2090-time horizons and for moderate and highest GHG emissions (RCP 8.5) for Burnaby were obtained from Cannon et al.,2020 (these are the values used in the Pacific Climate Impacts Consortium's Design Value Explorer Tool11) and climatedata.ca.

Other resources used to determine climate change-related hazard exposure include NRC's 2021 National Guide for Wildland-Urban Interface Fires12, Wildland Urban Interface Risk Class Maps13, regional floodplain mapping14, Intensity Duration Frequency (IDF) curves, and site topographic information.

The following table summarizes the assumptions involved with determining the climate-projected design values for this project.

[11] The PCIC Design Value Explorer tool provides historical and projected climate design data for Canada.

[12] This document provides guidance on determining the wildfire hazard at a site (Figure 6 and Table 3).

[13] Wildland Urban Interface Risk Class Maps https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/fire-fuel-management/wui-risk-class-maps/wui-downloads

[14] Floodwise flood maps https://floodwise.ca/flood-maps/lower-mainland-flood-management-strategy-flood-maps/

Table A.1 Assumptions for Determining Climate-Projected Design Values

Category	Assumption	Notes and Justification
Building's Design Service Life	Between 50 and 100 years	Based on Table 1 in CSA S478:19 "Durability in buildings," the design service life for low-rise commercial and office buildings is "medium," that is between 25 and 99 years (with 25 years being reported as the minimum). Based on consultant expertise, for this type of construction, we anticipate a service life of a minimum of 50 years; and 100 years would not be unrealistic. For reference, the construction of Engineers and Geoscientists BC building was completed circa 1994/1995, putting the current age of the building at approximately 30 years.
Time Horizons for Climate Projections	2050 and 2090	The time horizons were selected based on the design service life of the building. In 2050, the building will be approximately 55 years old, and in 2090, the building will be approximately 95 years old. Climate-projected design values are not readily available beyond 2100.
Emissions Scenario	RCP 8.5 from CMIP 5	The Pacific Climate Impacts Consortium (PCIC) Design Value Explorer Tool was built using the data from Cannon et al. (2020), hence it relies on the Coupled Model Intercomparison Project (CMIP 5) data. The high emissions scenario, Representative Concentration Pathway (RCP) 8.5 was selected. Although climate data is available using the CMIP 6 models (through climatedata.ca), design values are the preferred climate indicator for this project (it will allow comparison to the design values used during the design/construction of the building circa 1994, to what may be required for upgrades in the present or future day).
Global Warming Levels (GWLs)	+1.5 °C +3.5 °C	Based on the emissions scenario, and time horizons, the following GWLs above the 1986-2016 global mean temperature were determined to be of interest: • 2050: GWL of +1.5 °C • 2090: GWL of +3.5 °C

2.0 Climate Risk Identification

The 'Climate Risk Assessment' step of this project was based on the PIEVC High-Level Screen Guide (HLSG) and is consistent with Step 3 outlined in the "Climate Resilience Framework & Standards for Public Sector Buildings" (CRFS). The CRFS document provides detailed explanation and resources for how to conduct a climate risk assessment; it is a good reference for anyone looking to conduct their own assessment or who wants additional information. This section provides a short primer on how to calculate climate risk, and a summary of the key steps for the physical climate risk assessment conducted for Engineers and Geoscientists BC.

2.1 Overview of How to Calculate Risk Scores

For each of the major building systems (e.g. HVAC system) under a climate hazard event (e.g. extreme heat), a risk score is calculated. The calculation of a risk score accounts for:

1. The **likelihood** of a climate hazard event occurring and impacting a building or building component – this can be evaluated quantitatively or semi-quantitatively.
2. The **consequence** of the event taking place – this can be evaluated quantitatively or semi-quantitatively.
3. The **exposure** of an asset/building system to the climate hazard - if the site is deemed to have exposure to a certain hazard (which was predetermined during the 'Exposure Screen'), then the major asset classes was considered for exposure. If an asset had the possibility of being impacted by the climate hazard, then there is an exposure of the asset.

The **risk score** is the product of the above three components.

2.2 Summary of Key Steps for Physical Climate Risk Assessment

The main steps in the climate risk assessment for this project were as follows:

→ Step 1: RDH developed an initial list of the impacted building sub-systems across all major domains (mechanical, structural, electrical, civil & site, and building enclosure) based on design documents and information collected during the site visit. For each climate-related hazard the *exposure* of the system was assigned a 'Yes' or a 'No,' based on whether the system was impacted by the hazard. Consistent with the PIEVC HLSG, if there was any degree of impact on the system, a 'Yes' was assigned.

→ Step 2: The *likelihood* scores were assigned to each climate-related hazard event. For each climate-related hazard event one score was assigned to each time horizons being considered. Ratings and definitions for the likelihood score are provided in **Appendix C**.

→ Step 3: Based on knowledge of the building, context regarding the *consequence* of each climate-related hazard event on the building's performance, the building services, and occupant wellbeing was obtained (assuming the exposure was assigned a 'Yes'). Ratings and definitions for the consequence score are provided in **Appendix C**.

→ Step 4: A simplified risk score matrix was assembled where risk of each climate change-related event on the building's sub-systems was calculated.[15] The risk levels were categorized as 'low,' 'medium,' 'high,' or 'not applicable.' This is presented in **Appendix C**.

If a climate risk assessment determined that risk level for a system-hazard pair was deemed high, a strategy should be pursued to address/reduce the risk.

For the risks identified as medium, a further consideration of loads through a vulnerability analysis was considered.

[15] Risk is calculated as the product of the likelihood of an event happening, and the severity of impact (or consequence) that the event would have on the building performance (assuming that the building site/location has exposure to the climate hazard). The calculation followed the scoring presented in the PIEVC High-Level Screening Guide methodology.

3.0 Vulnerability Analysis

Vulnerability in the climate risk context is a building component's predisposition to be affected by a climate hazard due to its lack of capacity to cope and adapt.

Vulnerability analysis is conducted after the climate risk assessment.

The PIEVC guidance outlines the "Suggested PIEVC Assessment Processes" depending on the desired assessment outcome. For a "detailed risk assessment of public infrastructure (new, existing)," the guidance recommends either: 1) PIEVC High Level Screening Guide (HLSG) with an Engineering Analysis, or 2) PIEVC Protocol be used. For "Asset Management, Capital and Master Planning," the guidance recommends the HLSG. Given the desired outcomes of the project, availability of information, and resources for the project, a High-Level Screening Guide was more appropriate than the PIEVC Protocol. The main difference between the PIEVC HLSG and the full PIEVC Protocol is the level of detail involved at each step of the assessment.

We also incorporated a high-level Engineering Analysis. The high-level Engineering Analysis evaluated the vulnerabilities for the building components associated with medium risk scores; the assessment aimed to resolve any ambiguity with regards to the level of risk. High risk scores clearly identify that adaption strategies are required, so Engineering Analysis is not required in these instances. For the high-level Engineering Analysis, the historical and projected loads on key building systems were compared to the existing and projected capacities. Whenever the loads are expected to exceed the capacities, the infrastructure component is considered 'vulnerable.' This assessment was a "Yes" or "No" classification as we were not the original design engineer, and the design engineers involved in design of the project renewals would be responsible for sizing in the future (with timelines TBD). Assumptions were made related to historical design loads/capacities – wherever possible, these were inferred from construction drawings, our understanding of historical building code requirements and reported performance to-date.

4.0 Adaptation Strategies & Return on Resilience Investment

Based on the medium and high-risk scores identified, we used the Standards from the "Climate Resilience Framework and Standards for Public Sector Buildings" document (the Standards) as a key resource to develop a set of actionable recommendations for enhancing the building and site's resilience to climate-related hazards. We developed recommendations for any measures that require deviations from the Standards, that are not adequately covered by the Standards, and/or have been superseded by more current best practices since the Standards were written.

A high-level **return on resilience investment score** for each recommendation was developed, grouped by shorter- and longer-term strategies. This score was developed by the authors of this document. To determine the return on resilience investment score for each adaptation strategy considered, we evaluated the following four major parameters:

i. **Climate risk informed-importance score,**
ii. **Order of magnitude costs,**
iii. **Ease of implementation,**
iv. **Ease of operation/maintenance.**

For each of the four parameters evaluated, a score was assigned on a scale from 1 to 3 (where a ‘1’ is worst score and a ‘3’ is the best score). The scoring rubric is provided in the table below. As part of the evaluation, any important assumptions were also outlined.

From there, the scores from the four parameters were combined in a weighted average to arrive at an overall **return on resilience investment score** (between 1 and 3). The weighting used in the calculation is provided in the table below. For the return on resilience investment score, a ‘1’ is the worst score (or a *low* return on resilience investment) and a ‘3’ is the best score (or a *high* return on resilience investment). For our purposes, we deemed adaptation strategies with a return on resilience score above 2.5 as a high priority for implementation.

Table A.2 Return on Resilience Investment Score Parameters

Category	Scoring Rubric	Weighting
Climate Risk informed - Importance Score (Consultant Evaluation of Importance of the Standard)	1: Low - Addresses risk slightly 2: Moderate - Addresses risk moderately 3: High - Addresses risk fully	35%
Order of Magnitude Cost	1: greater than 10% increase of full system replacement cost 2: 2-10% increase over full system replacement cost 3: less than 2% increase over full system replacement cost	35%
Ease of Implementation & Feasibility	1: Low 2: Moderate 3: High	15%
Ease of Operation/Maintenance & Lifecycle Costs	1: Low 2: Moderate 3: High	15%

APPENDIX B: Summary of Future Climate Projected Design Parameters

	Climate Hazard/Trend	Climate Indicator *(wherever possible, code design values were used)*	Historical Code Value (1990 NBCC)	Current Code Design Value[7]	GWL of + 1.5°C 2050 Projected Design Value *(Relative Change from Present Day)*	GWL of + 3.5°C 2090 Projected Design Value *(Relative Change from Present Day)*	General Comments	Code Notes	Likelihood Score *(3 is the Baseline)*
Temperature	Heat Waves (Extreme Summer Temperatures)	Summer Design Temperature July 2.5% Dry (˚C)	25 [7]	25 [1]	28 (+3.3°C) [2]	33 (+7.9˚C) [2]	Extreme warm temperatures become hotter. Canada is warming more rapidly than the annual mean global increase.	○ 1990 Code - July dry bulb temperatures - temperatures that are exceeded 2.5% of the hours in July; 1957-1966 data for 109 stations averaged with 33 other stations from an older dataset. ○ 2020 Code Values were updated using hourly temperature observations from 480 stations for 25-year period up to 2006.	4 for 2050 5 for 2090
		Summer Design Temperature July 2.5% Wet (˚C)	17 [7]	17 [1]	20 (+2.6˚C) [2]	23 (+6.2˚C) [2]		○ 1990 Code - July wet-bulb temperatures obtained in similar way as dry bulb (refer to code for details) ○ 2020 Code - See dry bulb above	
	Cold Snaps (Extreme Winter Temperatures)	Winter Design Temperature January 2.5% Dry (˚C)	-7 [7]	-7 [1]	-4 (+3.4˚C) [2]	0 (+7.4˚C) [2]	Extreme cold temperatures become less cold, and less frequent.	○ 2.5% value is typically used for design of heating systems ○ 1990 Code hourly temperature distributions for the 10-year period 1951 to 1960 for 118 stations. Hourly data summaries based on the 10-year period 1957-1966 published for several stations each year since 1967. Now available for 109 stations. For 69 stations in both lists, current design temp is average of two and therefore is based on 16-year period 1951 to 1966. 89 stations that were only in one list were adjusted to be more consistent.	2
		Winter Design Temperature January 1% Dry (˚C)	-9 [7]	-9 [1]	-6 (+3.4˚C) [2]	-1 (+7.7˚C) [2]		○ 1% value is used when control of inside temperature is more critical ○ 2020 Code - See 2.5% above	
	Warmer Winters / Shorter Winters	Heating Degree-Days; Base 18.0˚C	3307 [7]	3100 [1]	2570 (-530 days) [2]	2031 (-1069 days) [2]	- Significant reduction in heating degree days (HDD). HDD are used to determine the climate zone. - Per NECB's definition of climate zones (CZ), the building will still be in CZ 4 (as it does not include a CZ definition lower than 4). - However, for comparison, in the USA, the S. Atlantic (e.g. North Carolina, Florida) have HDD of approximately 2500 in present day.	○ 1990 Code - degree days below 18˚C have been computed day by day for the length of record available between 1951 and 1980; published by AES. Accuracy +/- 100-degree days. ○ 2020 Code - compiled for 1300 stations for 25-year period ending in 2006	2
	Sea Level Rise / River Rise	Flood mapping	Not available	Not available. Refer to Flood Maps	Not available. Refer to Flood Maps [6]	Not available. Refer to Flood Maps [6]	Freshet flooding of the Fraser River does not result in a concern for this site as the site location has no exposure.[6]		-
Precipitation	Extreme Rainfall Events (& Associated Overland Flooding)	1/50 1-day Rainfall (mm)	172 [7]	150 [1]	170 (+13.3%) [2]	196 (+30.8%) [2]	- For future climate, precipitation increases due to 'temperature scaling' (i.e. moisture capacity of atmosphere increases because of temperature increase).	○ 1990 Code Maximum one day rainfall used for estimating additional load if roof drainage system becomes ineffective (to the point where accumulation of rainwater may be great enough to cause significant increase in load on the roof). Max. 1 day rainfall for several hundred stations were used from Atmospheric Environment Service. Noted that maximum is likely exceeded based on how these values are determined. ○ 2020 Code - Updated from 3500 stations with 10 years or more of record including data up to 2008 for some stations.[1] These values have a probability of exceedance of 1 in 50 in any given year.	4
		1/10 15min Rain (mm)	10 [7]	10 [1]	11 (+13.3%) [2]	13 (+30.8%) [2]	- There is a high level of uncertainty associated with 15min rainfall values (conventional climate models have longer time steps than 15min).	○ 1990 Code For roof drainage design. Based on measurements of the annual maximum 15min rainfalls at 139 stations with 7 or more years of record. ○ 2020 Code - Values update for 2010 code from 485 stations with 10 or more years of record including data up to 2007 for some stations. 1 Used Gumbel distribution. Values have a probability of exceedance of 1 in 10 in any year.	
	Increase in Total Precip. (& Associated Overland Flooding)	Annual total precipitation (mm)	1935 [7]	1950 [1]	2005 (+2.8%) [2]	2026 (+3.9%) [2]	- For the future climate, total annual precipitation is expected to increase; however, the component of precipitation that is snow-only is anticipated to decrease.	○ 1990 Code - 30-year period from 1951 to 1980 ○ 2020 Code - 1379 stations for 30 year period: from 1961-1990 ○ NBC 2020 precipitation values were interpolated from analysis of precipitation observations form 1379 stations for the 30-year period from 1961 to 1990.[1]	3
		Annual rain-only precipitation (mm)	Not available	1850 [1]	1961 (+6%) [2]	2011 (+8.7%) [2]			

	Climate Hazard/Trend	Climate Indicator *(wherever possible, code design values were used)*	Historical Code Value (1990 NBCC)	Current Code/ Present Design Value[7]	GWL of + 1.5˚C 2050 Projected Design Value *(Relative Change from Present Day)*	GWL of + 3.5˚C 2090 Projected Design Value *(Relative Change from Present Day)*	General Comments	Code Notes	Likelihood Score (3 is the Baseline)
Wind & Storm	Winter (Snow & Ice) Storms	1/50 Snow Load (Pa)	Not available. 1/30 ground snow load provided as 4400 Pa	2900 [1]	1737 (-40.1%) [2]	1070 (-63.1%) [2]	Snow cover duration is expected to decrease, with reductions in snow accumulation.	○ 1990 Code - Annual maximum snow on the ground assembled for 1618 stations from AES. The period of record used varies from station to station (7 to 38 years). Analyzed using the Fisher-Tippett Type 1 extreme value distribution. 1 in 30 year of being exceeded. The unit weight of old snow is assumed 2-5 kN/m^3 and new snow is 1 kN/m^3 ○ 2020 Code - Same data as above but with Gumbel distribution	2 for 2050 1 for 2090
		1/50 Rain Load (Pa)	Not available. 1/30 ground snow load provided as 600 Pa	700 [1]	484 (-30.8%) [2]	312 (-55.5%) [2]		○ 1990 Code - Heaviest loads frequently occur when snow is wetted by rain, so Ss is estimated. Values of Sr when added to Ss provide a 1 in 30 year estimate of the combined ground snow and rain load. Values of Sr are from 2100 climate stations of 1 in 30 yr one-day max. rain amount ○ 2020 Code - 2100 weather station values of the 1 in 50 year one-day maximum rain.	
	Strong Wind Events	1/50 Hourly Wind Pressure (Pa)	Not available	470 [1]	470 (+0.1%) [2]	508 (+8%) [2]	For high emissions scenario, minimal change for 2050 and greater changed in 2090	○ No value for 1990 Code ○ 2020 Code - Updated from 2010 code. Only data with > 20 years were used. 368 hourly and 222 daily peak wind gust stations with periods ranging from 20 to 65 years. Gumbel distribution.	3
		1/10 Hourly Wind Pressure (Pa)	490 [7]	350 [1]	353 (+0.8%) [2]	372 (+6.3%) [2]		○ 1990 Code - Annual max hourly wind speeds analysed to obtain hourly wind speeds that have 1 in 10, 30 a 100 year of being exceed in any one year. Using older hourly mileages (# of miles of wind that pass anemometer head in each hour). 100 stations using Gumbel's extreme value method. Values for an additional 500 locations were estimated. ○ 2020 Code - See 1/50 Hourly above. Small changes from 2010 code.	
	Wind-driven Rain Events	1/5 Wind Driven Rain Pressure (Pa)	Not available	160 [1]	172 (7.7%) [2]	178 (+11.1%) [2]			3 for 2050 4 for 2090
	Coastal Storm Surge	Flood Maps	Not available	Not available. Refer to Flood Maps[6]	Not available. Refer to Flood Maps [6]	Not available. Refer to Flood Maps [6]	Coastal storm surge flood scenarios for current sea level rise and a 1m sea level rise have no impact on this site (no exposure).[6]		-
Wildfire	Wildland Urban Interface Fire Events	Wildfire Hazard Level	Low Hazard Level [4]	Low Hazard Level [4] Low Risk Class Level [5]	Not available	Not available	○ There is anticipated to be increased wildfire activity (associated with increase in hot and dry weather). There are small parks within 500m of the building (e.g. Broadview Park). ○ Wotton et al. predicted an increase in wildfire occurrence in Canada of up to 140%. ○ The Province published Wildland Urban Interface Risk Class maps in 2021 showing that the office is generally located in a lower risk area; however, this has not been climate projected and is not site specific.		3
	Wildfire Smoke Events	Air Pollution (Wildfire Smoke Events)	Not available	Not available	Not available	Not available	○ Increased wildfire activity in the province will result in an increased number of wildfire smoke events. Wildfire smoke events can be from wildfires outside provincial boundaries. ○ Burnaby has experienced wildfire smoke events where PM2.5 concentrations exceeded World Health Organization's 24hr target of 15 ug/m^3. ○ Air quality data for 2010-2021 was investigated; the 98P daily averages in 2017, 2018 and 2020 were above WHO's target.[8]		4

[1] From National Building Code of Canada 2015/2020, Table C-2 - "Vancouver Region - Burnaby (Simon Fraser Univ.)".
[2] Climate projection using downscaled regional climate models. Refer to Appendix 1.2 in Cannon et al., "Climate-Resilient Buildings and Core Public Infrastructure" (2020). Used values for RCP 8.5 future scenario. These values are also available at PCIC Design Value Explorer Tool.
[3] From climatedata.ca
[4] Hazard level for Burnaby based on 30-year fire history. Fig. 6 in Benichou et al, "National guide for wildland-urban interface fires: guidance on hazard exposure, property protection, community resilience and emergency planning to minimize the impact of wildland-urban interface fires" (2021)
[5] Wildland Urban Interface Risk Class Maps https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/fire-fuel-management/wui-risk-class-maps/wui-downloads
[6] Floodwise flood maps https://floodwise.ca/flood-maps/lower-mainland-flood-management-strategy-flood-maps/
[7] An important note is that the Engineers and Geoscientists BC building received its building permit in 1994, so the current codified NBCC values are not the values that they were designed for. The design would have used BC Building Code 1992 (which was adopted in 01 Dec 92), which references NBCC 1990 Code Values are from the "Supplement to the National Building Code of Canada 1990"
[8] BC Air Data Archive Website

APPENDIX C: Likelihood Score, Consequence Score and Risk Score Definitions

Table C.1 Likelihood Scoring Criteria

Likelihood Score	Description
1	**50 - 100%+ Reduction** in frequency or intensity with reference to Baseline Mean
2	**10 - 50% Reduction** in frequency or intensity with reference to Baseline Mean
3 - Current Baseline	**Limited change (+/- 10%)** in frequency or intensity with reference to Baseline Mean
4	**10 - 50% Increase** in frequency or intensity with reference to Baseline Mean
5	**50 - 100%+ Increase** in frequency or intensity with reference to Baseline Mean

The above table scoring method is consistent with that presented in the PIEVC High Level Screen Guide (HLSG) guidance.

It uses the “middle-baseline” scoring method, where the mean conditions over the historical time period are represented as a 3. Using the time period chosen for evaluation climate change projections, the likelihood score is assigned depending on the percent change (increase/decrease) from baseline frequency or intensity.

Table C.2 Consequence Scoring Criteria

Consequence Score	Description	Sub-criteria					
		Financial	Reputation	Operations	Health & Safety	Environment	Level of Service
1	Very Low	< $25,000	No/negligible negative impact on public perception	Negligible	Appearance of threat but no harm	Appearance of threat or short-term irritants, but no harm. No impact to sustainability goals	Isolated, short-term (one day or less) periods of not delivering target levels of service
2	Low	$25,000 to $50,000	Very brief (1-2 weeks) negative impact on public perception	Normal administrative/ operational difficulties	Serious near misses or minor injuries	Minor instances of environmental damage that could be reversed. Minor impact to sustainability goals	Short-term (several days to one week) interruption to target levels of service
3	Moderate	$50,000 to 100,000	Short term (1-6 months) negative impact on public perception	Delay in accomplishing objectives	Small number of injuries that require medical consultation	Isolated but significant instances of environmental damage that might be reversed with intensive efforts. Major impact to sustainability goals.	Noticeable impacts to quality of life due to occasional long-term periods of service interruption, OR noticeable permanent decline of level of service
4	High	$100,000 to $1,000,000	Medium term (6 months to 1 year) negative impact on public perception	Medium term non-routine measures needed before objectives can be met	Isolated instances of serious injuries, chronic health impacts or fatality	Sever loss of environmental amenity or continuing environmental damage.	Substantial decline in quality of life due to frequent long-term periods of service interruption OR substantial permanent decline of level of service
5	Very High	> $1 million	Long term (> 1 year) negative impact on public perception	Some objectives will not be met. Long-term non-routine measures needed	Large number of serious injuries or loss of multiple lives	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Complete service interruption for an indefinite period, leading to major decline in quality of life

Note that the “Consequence Score” and “Description” columns in the above table are consistent with the PIEVC High-Level Screening Guide scoring criteria. We added some additional “Sub-criteria” (Financial, Reputation, Operations, Health & Safety, Environment and Level of Service) to help ensure consistency with the consequence score evaluation. Note that for assigning a certain score for an asset – hazard pair, the most serious consequence sub-criteria typically dictated the consequence score assigned. Not every asset – hazard pair was necessarily evaluated for all criteria if their consequence was low or negligible. For example, if one scenario had a Financial consequence of “$50,000-$100,000,” a Reputation consequence of “Very brief (1-2 weeks) negative impact on public perception” and a Health & Safety consequence of “Serious near misses or minor injuries,” the consequence score that was assigned was a ‘3’.

Table C.3 Risk Scoring Definitions

5	CONSEQUENCE SCORE	5	10	15	20	25
4		4	8	12	16	20
3		3	6	9	12	15
2		2	4	6	8	10
1		1	2	3	4	5
		LIKELIHOOD SCORE				
		1	2	3	4	5

Risk Score Categories:

- **Grey (1-9) → Low Risk**
- **Yellow (10-19) → Medium Risk***
- **Orange (20-25) → High Risk**

* Although, note that from the categories listed above, unless fractions are used, the upper bound for medium risk score is 16 (see matrix).